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NEW WILTRON CONNECTOR RELIEVES NAGGING SMA MEASUREMENT PROBLEMS

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WILTRON

NEW CONNECTOR RELIEVES NAGGING SMA MEASUREMENT PROBLEMS

SMA connectors are widely used throughout the industry because of their small size and broadband characteristics. However, their low reliability in applications requiring frequent reconnects has discouraged their use on test components and instruments. Test engineers have commonly used error-producing adaptors to mate type N or APC-7 instrument connectors to SMA test devices. The accuracy of SMA reflection measurements has left much to be desired.

To meet the need for a connector with longer life and greater accuracy in instrumentation applications, WILTRON has developed a new SMA-compatible connector, the WSMA. When used as the test port on reflection-measuring components, the new connector provides a 20-fold improvement in life expectancy and a 10dB improvement in SWR measurement accuracy. A problem which has plagued test engineers and instrument manufacturers for fifteen years has been greatly relieved.

Several WILTRON measurement components with the new WSMA connector are now available. As described later in this paper, the new components include an SWR Autotester which makes reflection (return loss) measurements over the 10MHz to 18GHz range with 38dB directivity, a precision APC-7/WSMA adaptor and an air line reference standard.

NEW WSMA DESIGN

To achieve a dramatic improvement in life expectancy, a new WSMA female connector was developed. The design consists of a tube within a tube. (See Figure 1.) The inner tube is slotted to form fingers which assure simultaneous contact with the male pin and the inner surface of the outer tube. The outer tube is smooth and unslotted, providing performance which is free of resonances and reflections. (Earlier work on a similar design by Dr. Bruno Weinschel is described in the reference.) The outer tube is press-fitted, while the inner tube is screwed into the center conductor.

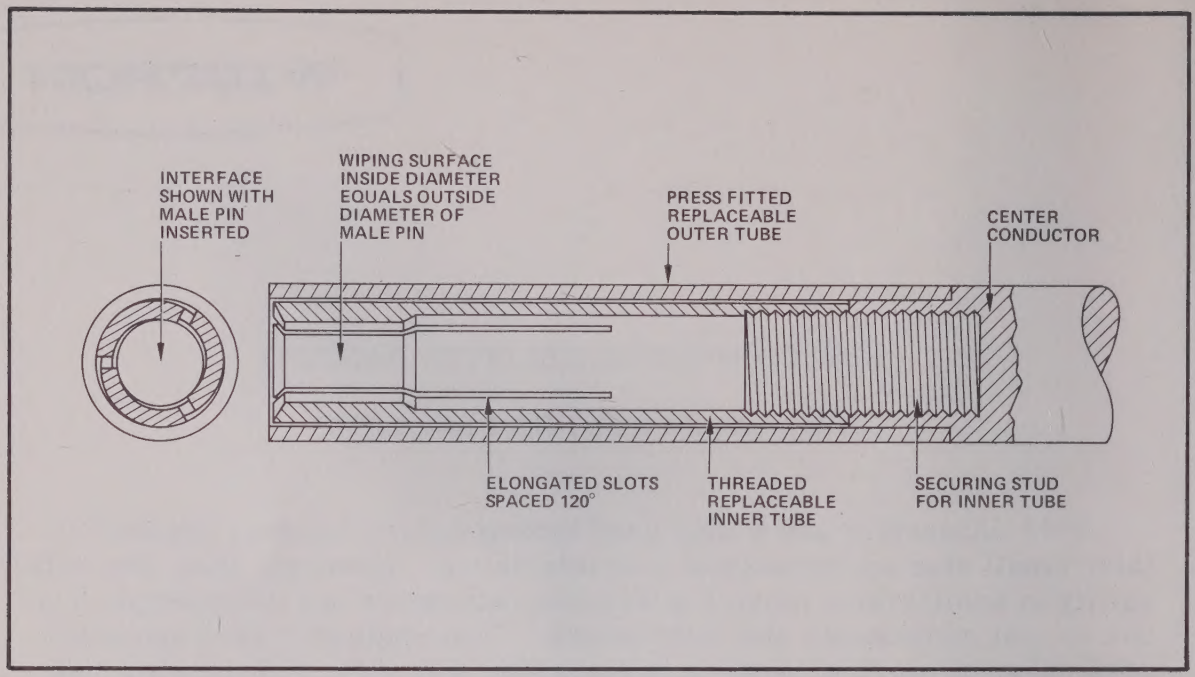

INTERFACE SHOWN WITH MALE PIN INSERTED
WIPING SURFACE INSIDE DIAMETER EQUALS OUTSIDE DIAMETER OF MALE PIN
PRESS FITTED REPLACEABLE OUTER TUBE
CENTER CONDUCTOR
ELONGATED SLOTS SPACED 120°
THREADED REPLACEABLE INNER TUBE
SECURING STUD FOR INNER TUBE

Figure 1. WSMA center conductor design distributes pressure between male pin and slotted inner tube over large wiping surface area.

The WSMA includes several innovative design features:

1. The diameter of the inner tube's wiping surface is equal to that of the male pin. Full surface contact and minimum wear are assured.

2. The inner center-conductor tube is mechanically supported by the outer tube. Angular distortion and breakage caused by center conductor misalignment are reduced substantially.

3. Chamfers on the front and back side of the wiping surface prevent the male pin from being skived or worn excessively by sharp surfaces.

4. The effects of over-torquing are greatly reduced by the use of an air dielectric, which allows the outer tube wall thickness to be twice that of the SMA design.

5. If damage should occur, the inner and outer tubes may be easily replaced in the field.

The mechanical design meets the electrical requirements and withstands 30, 000 connections without significant degradation in performance.

A conventional SMA connector is shown in Figure 2.

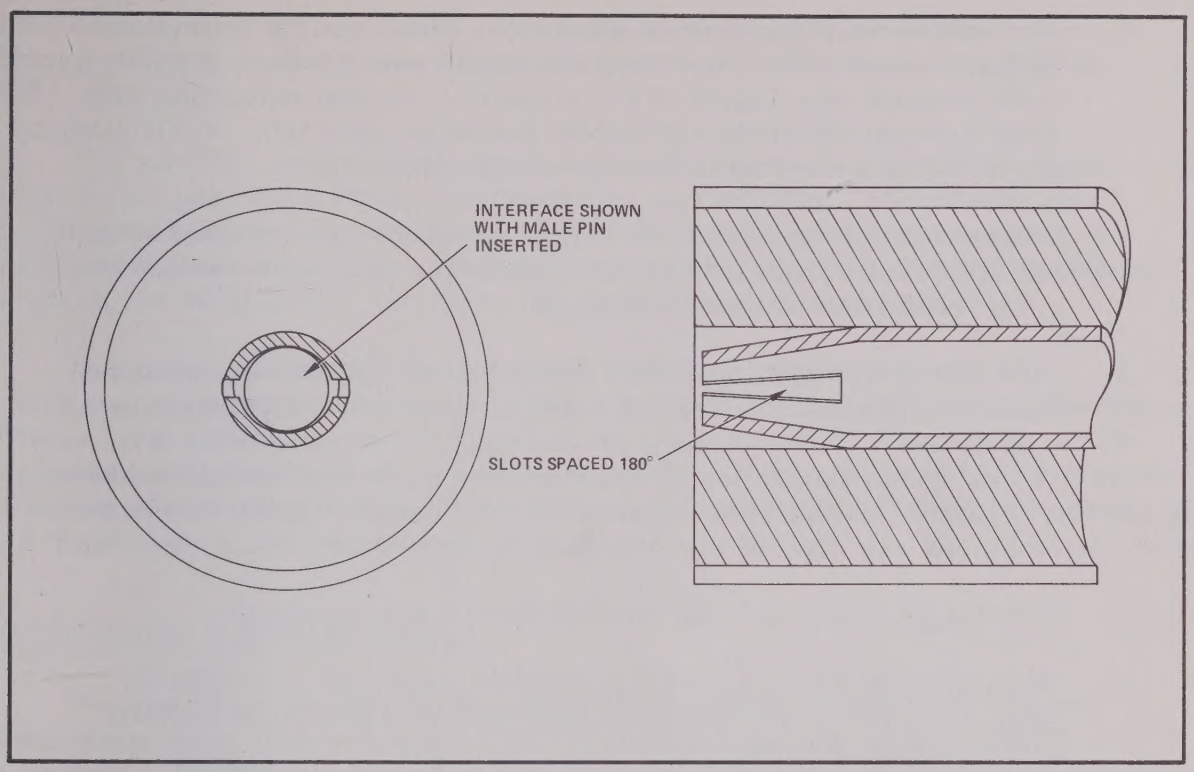


Figure 2. SMA connector consists of a tapered center conductor that is slotted in two places and surrounded by teflon dielectric. As shown in the end view, pressure on male pin is concentrated at points midway between the slots.

NEED FOR REFERENCE STANDARD

The accuracy of any microwave measurement is ultimately determined by the reference standard used. For reflection measurements, the standard is the impedance of a transmission line. Lacking a precise reference standard, test engineers have accepted the fact that SMA reflection measurements inherently involve considerable uncertainty. For example, if a bridge or directional coupler with a directivity of 30dB is used to measure a component with a 21dB return loss, there is a 6dB error window. The actual return loss can fall anywhere between 18dB and 24dB. The error range of a 30dB return loss measurement is unlimited. Without a precise SMA reference standard, there has been little hope for achieving the reflection measurement accuracy demanded by today's test engineer. To improve accuracy, WILTRON had to develop a new reference standard.

DESIGN OBJECTIVES FOR REFERENCE STANDARD

Because teflon is heat sensitive and subject to creep and movement, an SMA transmission line is inadequate as a reference standard. The development of a standard with an improved connector required a clean break away from the conventional SMA design. Only then could the following goals be reached:

1. The connector's performance had to be measureable against an accepted standard. Since the reference standard for any reflection measurement is a length of air dielectric transmission line, all solid dielectrics (including teflon) had to be rejected. In all respects the new connector had to be a precision device.

2. The relatively rapid wear or distortion of the conventional SMA female center-conductor and the distortion of the thin-walled male outer-conductor had to be avoided.

3. The new design had to be SMA compatible. Reflection test data taken on SMA devices from a WSMA test port had to be accurate.

As soon as it was theoretically proven that a precision interface between an air line (3.5mm) and an SMA connector with a teflon dielectric was possible, development was divided into two manageable tasks:

1. The design of a precision air line (reference standard).

2. The development of a center conductor which would minimize wear and provide the required interface between the WSMA air and SMA teflon dielectrics.

NEW REFERENCE STANDARD

The WSMA air line reference standard is constructed using a 3.5mm air line with beadless WSMA connector on the test port end and a WSMA

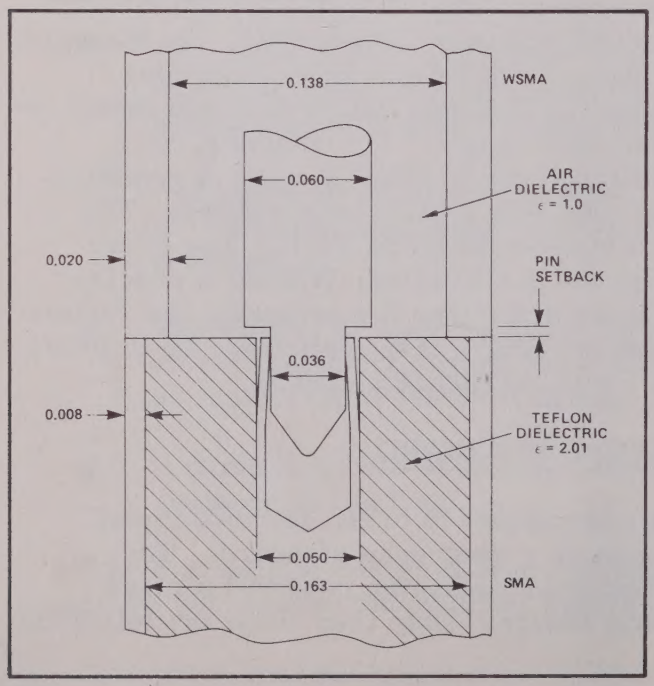


Figure 3. New WSMA mates directly with SMA. The greater wall thickness of the WSMA provides additional mechanical strength. The pin setback distance is a major factor in determining interface characteristics.

beaded connector on the other. The bead permits precise adjustment of the air line pin setback (see Figure 3) to assure optimum mating with an SMA connector.

The air line center conductor is made of thin-walled stainless steel, plated with gold over silver for maximum conductivity. By closely controlling tolerances, impedance is held to 50 ± 0.1 ohms, representing a 60dB effective return loss. With an accurate reference standard, measurement of the WSMA/SMA interface characterics is then possible.

Measurement of the WSMA to SMA interface required precisely machined SMA male and female connectors with accurately known impedance. These SMA connectors were machined directly on rigid, 30cm long, thick-walled coax lines which were specially drawn. Impedances of 50 ± 0.2 ohms were verified, using a Time Domain Reflectometer and a 7mm air line as an impedance standard.

INTERFACE MEASUREMENTS

The interface measurements which determined the optimum pin setback were made first using the SMA dielectric line with WSMA/APC-7 adaptors. The return loss of the adaptors was determined by moving the WSMA pin forward and backward until a null was achieved at the best return loss value. The measured return loss of the adaptor/termination combination was 38dB up to 18GHz. A pin setback variation of 0.0005" was easily detected. Five dielectric lines were tested to confirm the data.

Next, the air line with an SMA/APC-7 adapter was substituted for the dielectric line with the WSMA/APC-7 adapter. Again, the pin setback was adjusted for best return loss. The test data agreed very closely with that taken with the dielectric line.

When two WSMA connectors are mated, the gap formed by the pin setback causes an inductive mismatch, which masks the true reflection. This mismatch is eliminated by reducing the diameter of the outer tube at the interface with a 0.001" thick washer, the capacitance of which compensates for the gap inductance. Because the WSMA/WSMA field configuration with the washer in place closely approximates that of an air/dielectric interface, there is no degradation in accuracy when two WSMA connectors are mated. The washer is not required when an SMA is mated with an WSMA.

AVAILABLE WSMA COMPONENTS

The impact of the new WSMA design is far reaching. SMA reflection measurements can now be made with greater accuracy, over a longer life span, and with the convenience of field replaceable parts. WILTRON's rapidly expanding line of WSMA measurement components already includes:

SWR Autotester (Directional Bridge/Detector)

The WILTRON SWR Autotester (see Figure 4) integrates in one small package a microwave version of the Wheatsone bridge, a precision termination, an RF detector, and a WSMA test port.

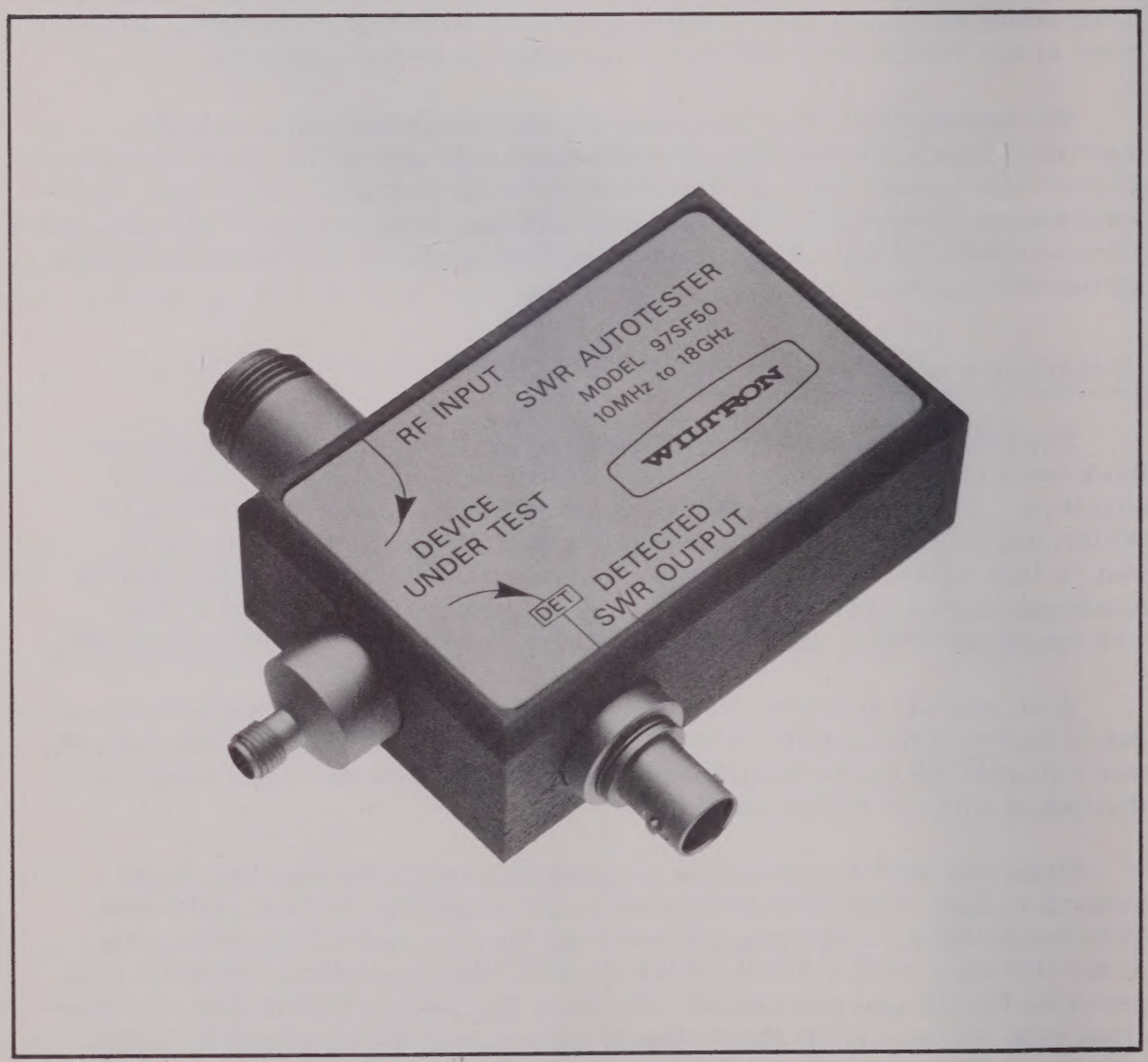


Figure 4. New WSMA connectors are available on 10MHz to 18GHz SWR Autotester with 35dB or 38dB directivity.

Operating over the full 10MHz to 18GHz range, these units are available with directivities of 35dB (97S50) and 38dB (97S50-1). Table 1 lists detailed specifications. Typical characteristics for the 97S50 are shown in Figure 5.

Table 1. SWR Autotester Specifications

Model	Frequency Range	Test Port Connector	Directivity (Minimum)	Frequency Sensitivity (Maximum)	Insertion Loss (Nominal)	①② Accuracy	
						10mHz-8GHz	8GHz-18GHz
97S50 97SF50	10MHz-18GHz	WSMA Male WSMA Female	35dB	±1.5dB	6.5dB	$0.018 \pm 0.08\rho^2$	$0.018 \pm 0.12\rho^2$
97S50-1 97SF50-1	10MHz-18GHz	WSMA Male WSMA Female	38dB	±1.5dB	6.5dB	$0.013 \pm 0.08\rho^2$	$0.013 \pm 0.12\rho^2$

All Models

Detector Output Polarity: Negative
SWR Output Time Constant: 2μs
Maximum Input Power: 0.5 Watt
Input Connector: Type N Female
Stainless Steel

Detector Output Connector: BNC Female
Dimensions: 3" x 2" x 1-1/8"
(7.6 x 5 x 2.8 CM)
Weight: 12 oz (340 grams)

① Including effects of test-port reflections.

② Where ρ is the measured reflection coefficient.

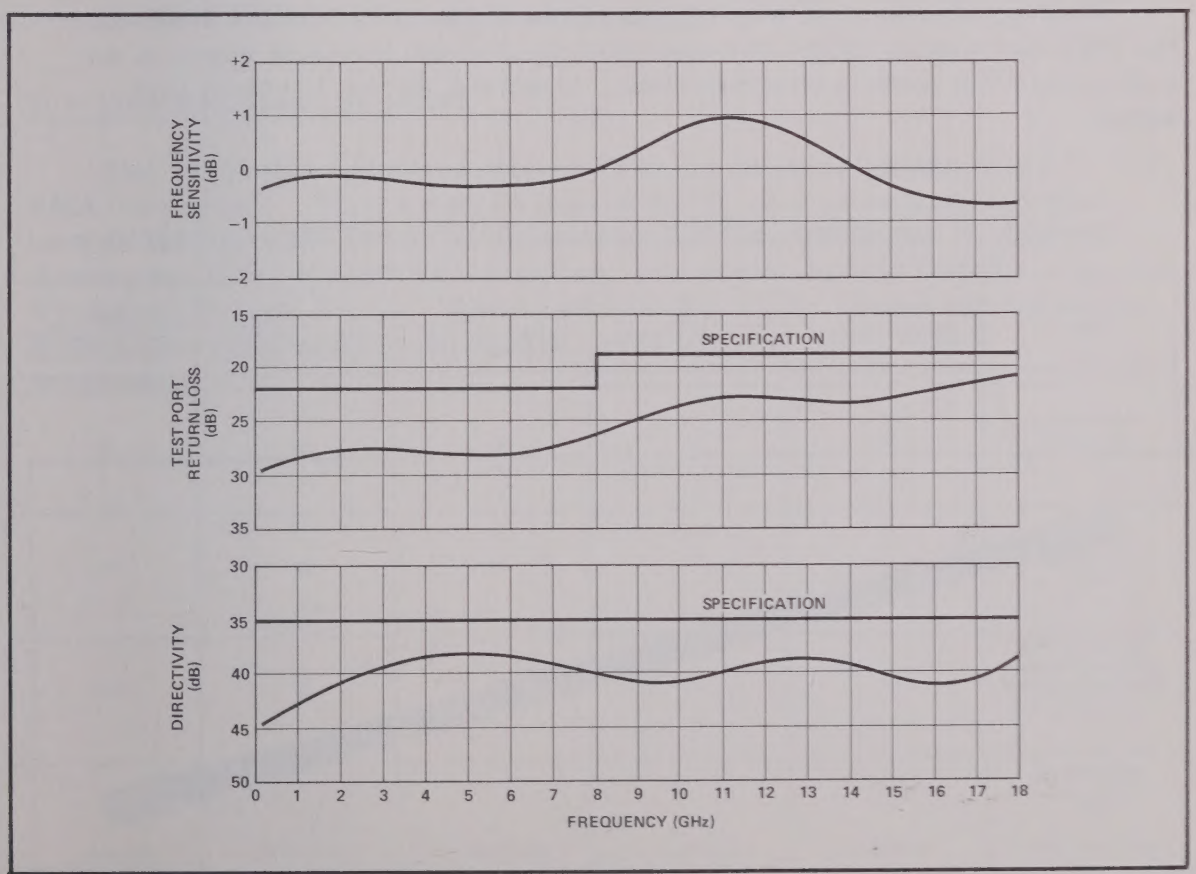


Figure 5. Typical characteristics of 97S50 SWR Autotester with WSMA test port.

The advantages of making reflection measurements directly from a WSMA test port over making them through an adaptor are evident from the comparison of Table 2. Several conclusions may be drawn:

The 97S50 with its WSMA test port has a 9.5dB greater directivity than the 97A50 with an APC-7/SMA adaptor. This improvement represents a 7.9dB reduction in the measurement error range of a 20dB return loss.

When an APC-7/WSMA is used in place of an APC-7/SMA adaptor, there is a 4.5dB improvement in effective directivity. For a 20dB return loss measurement, the improvement in error range is 4.1dB.

If the WSMA test port is used directly without adaptors, it provides a 5dB to 9.5dB improvement in directivity.

When used with a GPIB programmable 610D/6247D Sweep Generator, the SWR Autotester offers the operator the convenience and speed of an automatic SWR measurement system. Figure 6 shows a typical test setup.

Table 2. Comparison of SWR Autotester With and Without Adaptors

SWR Autotester Model	97S50-1 (WSMA Test Port)	97S50 (WSMA Test Port)	97A50-1 (APC-7 Test Port with WSMA Adaptor)	97A50 (APC-7 Test Port with WSMA Adaptor)	97A50 (APC-7 Test Port with SMA Adaptor)
SWR Autotester Directivity (dB)	35	35	40	36	36
Adaptor Return Loss (dB)	---	---	36	36	31
Combined SWR Autotester/Adaptor Effective Directivity (dB)	33	35	32	30	25.5
Measurement Error Limits: (dB)					
Return Loss of 26.5	24.5-29.0	23.7-31.5	22.7-32.5	21.7-33.0	20.9-∞
Return Loss of 20.0	19.0-21.3	18.5-21.7	18.3-22.5	17.7-23.7	16.4-26.5

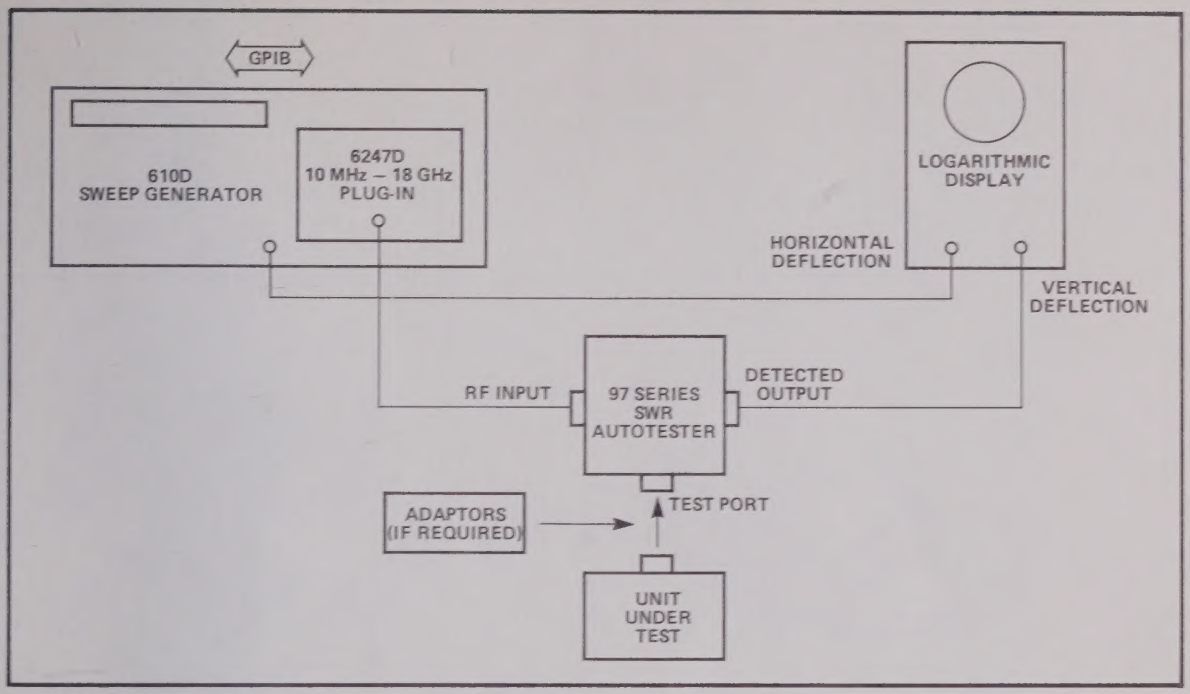


Figure 6. SWR Autotester used with GPIB programmable sweep generator provides automatic reflection measurements over 10MHz to 18GHz range without interruption to change components or to recalibrate.

Air Line Reference Standard

The 19S50 Air Line (see Figure 7) is a reference standard for SMA connectors. With a return loss of 50dB, this 24cm long component is ideally suited to reflection measurements using the "Ripple Averaging" and "Magnified Reflection" techniques in WILTRON Technical Review No. 8. These methods yield SWR measurement accuracies previously unobtainable, even with computer-aided systems.

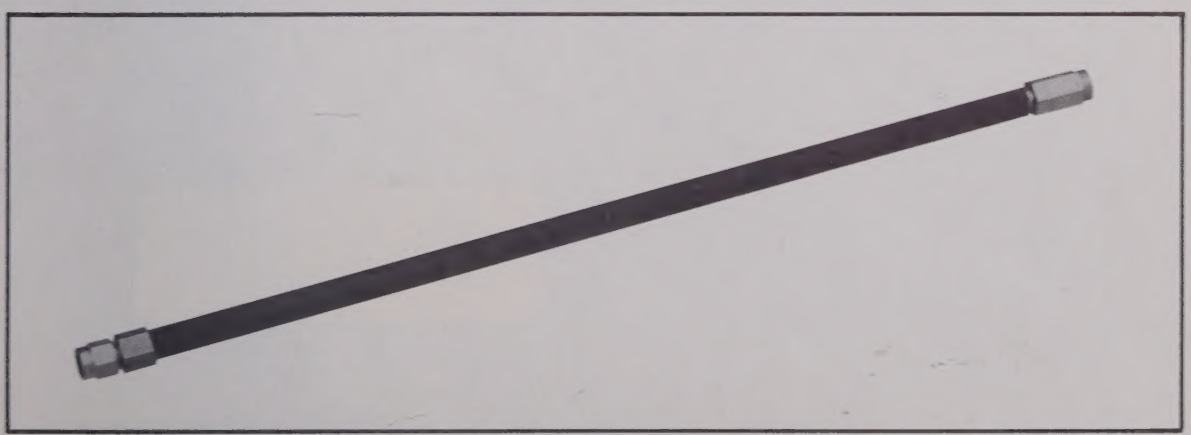


Figure 7. The 19S50 Air Line Reference Standard introduces a new level of accuracy to reflection measurements.

WSMA/APC-7 Adaptors

The 34 series adaptors (see Figure 8) feature longer operating life and a 36dB minimum return loss over the 10MHz to 18GHz frequency range. The adaptors are measured individually instead of in pairs, as is the usual practice.

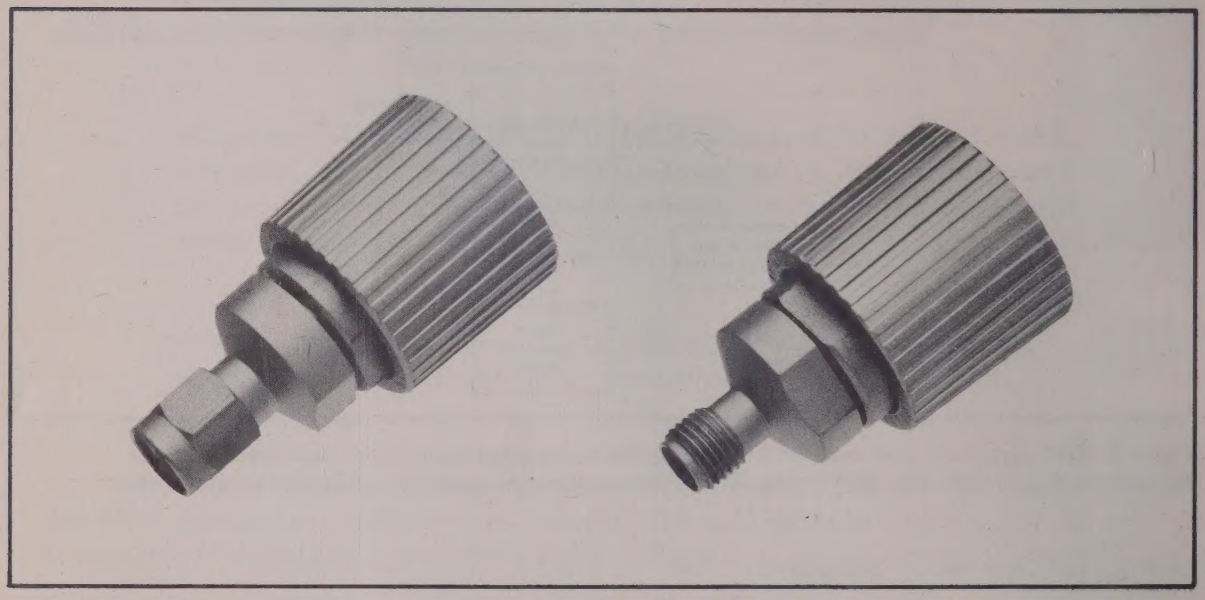
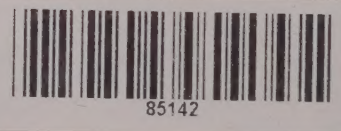


Figure 8. New APC-7/WSMA Adaptors offer longer life and 36dB return loss up to 18GHz.

IMPORTANT ADVANCEMENT

The development of the WILTRON WSMA connector represents an important advancement in the art of microwave SWR measurements. This new device removes the major obstacles which have limited the accuracy, life, and repairability of the conventional SMA connector.

- William W. Oldfield



Reference

"Progress in Type N Precision Connectors," March 1966, by Dr. Bruno Weinschel.